NEW YORK CITY'S WATER SUPPLY

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New York City's Water Supply

,ources of Supply—System of Distribution—Quantity Consumed—Cost of Water—Amount of Water Revenues—Prevention of Water Waste—Equalization of Water Rates.

By Walter E. Spear,

ARTICLE I.—SOURCES OF NEW YORK'S WATER SUPPLY.

URROUNDED by tidal waters on the rocky island of Manhattan, an ade-iate supply of water for domestic and dustrial purposes could only be ob-ined for New York City, as the com-unity increased in area and population, going back into the highlands of the ate, many miles from the city. The ·st public water supply of any impor-nce was thus brought to the city from the Croton river in Westchester and Putnam counties, through the Old Cro-ton Aqueduct, a structure of brick and rubble masonry, 34 miles long, carrying about 80 million gallons per day.

The Croton Aqueduct.

This aqueduct which is now a familiar landmark on the hillsides of Westches-ter county, reaches the present city line in Van Cortlandt park, east of Jerome avenue, and follows the surface of the higher ground in The Bronx and upper Manhattan island to its terminus in the Central Park reservoirs. Except for an occasional granite ventilating shaft, the old aqueduct is quite lost in the built-up streets of the city, but the picturesque Highbridge, in which the aqueduct in iron pipes crosses the Harlem river, is at once one of the most conspicuous and one of the most beautiful of our public works. The Croton watershed has been more completely developed since the first ipply was introduced; many additional ...oirs have been built and, ... oton Aqueduct, 31 ... of 300 ... City for the Croton supply was provided in the Jerome Park reservoir, one-half of which was completed in 1905.

Water from the Bronx river in West-chester county was first brought to the city as an emergency supply in 1884. This supply was carried through a steel pipe line to the Williamsbridge reservoir located near Woodlawn cemetery; a sup-ply from the Byram river was introduced through the same pipe line in 1897. Supplemented by the small supplies from the Bronx and Byram sources, the Cro-ton watershed still provides for the en-tire needs of the boroughs of Manhattan and The Bronx.

Brooklyn Sources.

Brooklyn, though situated even farther than New York from the upland sources of water supply, has been fortunate in being able to find large supplies of under-ground water in the coarse sands and gravels of Long Island, within and ad-jacent to its borders. Although the early needs were met by small local suppl from these sources, the first public wat supply of any consequence was derive from the flows of the small surfac streams on the south shore of Long Is land between the city and the village o Hempstead.

This supply was first delivered in 185 through the "Old Brick Conduit," 1 miles in length, which was built to carr 75 million gallons of water daily to the Ridgewood pumping station. From this station, which was constructed near t e...terly limi... of the present borou ...lyn ... was pumped ... Ridge-

gradually developed by means of driven well stations. These underground waters, the possibilities of which were not at first recognized as a source from which any large amount of water could be drawn, are now the chief dependence of the borough of Brooklyn.

In 1890 the Ridgewood works were extended along the south shore of Long Island to the easterly limits of Nassau county. The small streams were intercepted as on the original works, and the ground water subsequently developed through the construction of driven well stations and infiltration galleries. For the delivery of these waters the "New Brick Conduit," 7½ miles in length and of 65 million gallons capacity, was built. This conduit delivers it supply from the easterly watershed to Millburn station, which pumps the water through three cast-iron pipes, in part to the "Old Brick Conduit" and in part directly to the Ridgewood pumping station. Additional conduit capacity has since been provided by the construction of a 72-inch steel pipe line from a point near Ridgewood station to the east end of the collecting works. Besides the Ridgewood system, the city operates within the limits of Brooklyn borough, three independent driven well stations which pump ground water directly into the distribution mains. Several large areas in Brooklyn are similarly served by private water companies.

Except for a small supply from the .idgewood system which has recently een diverted from Brooklyn, all por- .ons of Queens borough are served with round water from local driven-well sta- .ons which deliver their supplies either nto stand-pipes or directly into the dis- ribution mains. Some of the local upply is furnished by the City but by ar the larger part by private water companies. In Staten Island, the city supplies practically the entire needs of Richmond borough with ground wa- , pumped, as in Queens borough from al driven well st- o st- or direct-

is shown in Table 1.

TABLE I.

DEPENDABLE YIELD OF NEW YORK CI PRESENT SOURCES OF WATER SUPPLY

Source	*Drain-age Sq. Mi. Area*	*Sc Yiel Mili per d Gal.*
Municipal Works		
Croton	360	336
Bronx and Byram	22	15
Ridgewood	159*	120
Brooklyn Driven Well Stations	...	12
Queens Driven Well Stations	...	6
Richmond Driven Well Stations	...	
Total Municipal Works		49
Private Water Companies		
Brooklyn	...	15
Queens	...	20

In many years, with large and favc ably distributed rainfalls, the yields many of these sources have exceed the above estimates and much water h gone to waste. The yields under such ra fall conditions do not, however, form a proper basis on which to estimate the amount of dependable supply. This must be based upon the yield during a period of several years of deficient rainfall when the draft from the watershed is largely maintained from storage in the reservoirs. In a properly proportioned storage reservoir, some loss of water over the spillway is at times unavoidable. The amount of water, for example, which occasionally runs to waste over the spillway of the New Croton dam, in years of large rainfall, could only be saved by building additional reservoirs on the watershed. Assuming that there were sites on which to construct such reservoirs, they would cost an amount of money quite out of proportion to the increase in the supply thereby effected. If the existing reservoir capacity on the Croton watershed be compared with that on the water sheds of other large water supplie this part of the countr watershed is fo nomic

venture, as would the construction of a group of hotels to provide accommodations for the sole demands of a convention, which let us say, meets at irregular intervals, averaging perhaps two or three times in ten years. Assume that the ordinary demand for hotel accommodations be approximately constant, like the rainfall, and the analogy is complete. The hotels like the new reservoirs would be empty most of the time, both would deteriorate and both would be an unprofitable investment for the owners.

The Catskill Supply.

After many periods of water shortage and much agitation, the city took steps in 1905 to develop new sources of water supply in the Catskill Mountains. A large storage basin, the Ashokan reservoir, has since been created by the construction of a large concrete masonry dam on Esopus creek, which is in Ulster county not far from Kingston. From this reservoir a concrete masonry aqueduct has been constructed, partly along the surface, partly in rock tunnel. The Catskill aqueduct crosses beneath the Hudson river at Storm King and passes through the Croton watershed to New York City on a location somewhat to the east of the Croton aqueducts Another storage basin, Kensico reservoir, has been built on the line of the Catskill aqueduct near Valhalla, at the site of the old Bronx River reservoir, for the purpose of maintaining the supply of the city when the aqueduct north of that point, is temporarily out of service. Still another basin, Hill View reservoir, has been constructed on a hill in Yonkers, just over the city line, to equalize the delivery of water to the city. From Hill View reservoir, the Catskill aqueduct has been continued as a deep rock tunnel, known as the City tunnel, through the boroughs of The Bronx and Manhattan to the borough of Brooklyn. Through the 22 waterway shafts of the City tunnel, the Catskill supply will be delivered directly to the street mains in those boroughs, and from the Brooklyn terminal shafts large pipe conduits have been laid in the streets to supply the boroughs of Brooklyn, Queens and Richmond, terminating at Silver Lake reservoir in the last borough. The Catskill acqueduct has a length from the Ashokan reservoir to Hill View reservoir of 91 miles, to the terminus of the City tunnel in Brooklyn 110 miles, and to the end of the pipe conduit at Silver Lake reservoir in Staten Island 120 miles. The works now approaching completion will safely furnish a daily supply from the Esopus watershed of 250 million gallons and the final completion of the Catskill system, through the development of the Schoharie watershed as now planned, will provide a daily supply of water amounting to 500 million gallons.

Yield of All Sources.

Upon the completion of the Catskill works the safe yield in million gallons per day of the gravity sources of supply from surface streams in Westchester, Putnam and Ulster Counties will be as follows:

Croton	336
Bronx and Byram	15
Catskill (Esopus and Schoharie watersheds)	500
Total of gravity sources	851

Adding to this amount, yields estimated in Table I for the non-gravity sources of surface and groundwater supply in Long Island and Staten Island, belonging both to the municipality and to private water companies, the total available supply of water from all sources when the Catskill works are finished will be 1,033 million gallons per day.

ARTICLE II. DISTRIBUTION OF SUPPLY AND AMOUNT OF CONSUMPTION

The introduction of the Catskill water supply will permit the abandonment for some years of the expensive pumped supplies of the boroughs of Brooklyn, Queens and Richmond and the proposed changes in the distribution system throughout the city will effect great improvement in the water pressure of many districts.

Boroughs of Manhattan and The Bronx.

As already explained in the previous article, the surface water supplies of the boroughs of Manhattan and The Bronx flow to the city by gravity from the upland watersheds. The flow from

the Croton watershed, which in 1915 amounted to an average supply of 323 million gallons per day, reaches Jerome Park reservoir at an elevation of 134 feet above sea level, and the Central Park reservoirs at an elevation of 119 feet; the Bronx and Byram supply, which in 1915 was 18 million gallons per day, arrives in the Williamsbridge reservoir at an elevation of 193 feet and goes directly to the consumers in The Bronx Intermediate service without pumping. About 70 per cent. of the Croton supply, or 224 million gallons per day, is delivered by gravity from the Jerome Park and Central Park reservoirs to the distribution mains of the Low services of The Bronx and Manhattan boroughs; the remainder is pumped to the higher services. Approximately 5 per cent. of the Croton supply, amounting to 16 million gallons daily, is pumped at the Jerome Avenue station to the Williamsbridge reservoir for The Bronx Intermediate service to supplement The Bronx and Byram supply and about 3 per cent., or 11 million gallons, is delivered daily at the same station to The Bronx High Service, the elevation of which is controlled by the stand pipe in that station at elevation 303. The Manhattan Intermediate service, which comprises most of the high ground in that borough, and which takes about 20 per cent., or 65 million gallons per day, of the Croton supply, receives a part of this supply from Highbridge reservoir at an elevation of 218 feet. Water is pumped to this reservoir at the 179th Street station. The southerly half of the Intermediate service is supplied by the 98th Street pumping station. The Manhattan High Service, which is located on the highest ground on Washington Heights, takes 2 per cent. of the Croton supply, or 7 million gallons per day. This is delivered at elevation 336 from High Bridge Tower and is supplied by the 179th Street pumping station. Reserve pumping capacity is provided at the High Bridge pumping station.

Borough of Brooklyn.

It was shown in the previous article that all the surface and groundwater supplies of the boroughs of Brooklyn, Queens and Richmond are pumped. The Ridgewood supply, which in 1915 averaged 123 million gallons per day, is pumped by Ridgewood station, about 85 per cent., or 105 million gallons per day, being raised to an elevation of 172 feet in the Ridgewood reservoirs, the remaining 15 per cent., amounting to 18 million gallons per day, being pumped to an elevation of 200 feet in the Mt. Prospect reservoir for the Brooklyn Intermediate service. Of the 105 million gallons of water delivered daily into the Ridgewood reservoirs, about 71 per cent. of the entire Ridgewood supply, or 88 million gallons per day, flows by gravity to the Low service of Brooklyn, 6 per cent., or 7 millions gallons per day, goes to Queens borough, and 8 per cent., or 10 million gallons per day, is pumped at the Mt. Prospect station from the Low service mains to Mt. Prospect Tower at an elevation of 280 feet for the supply of the Brooklyn High service. In addition to the Ridgewood supply, the Brooklyn Low service is supplied by direct pumping from three local driven-well stations which delivered, in 1915, 12 million gallons per day.

Boroughs of Queens and Richmond.

The First and Third Wards of Queens borough are served by municipal works which delivered in 1915 an average daily supply of 13 million gallons. The local driven-well stations in Queens borough furnished 46 per cent. of this supply at elevations between 148 and 221 feet; the remainder came from the Ridgewood works of Brooklyn at elevation 172. In Richmond borough, where the highest ground in the city is found, about 10 per cent. of the total municipal supply of 12 million gallons per day, is pumped to an elevation of 453 feet; but the remaining 90 per cent. is delivered between elevations 212 and 254 feet, except for a very small amount which is supplied at elevation 143.

The amounts and sources of the water supplied in 1915 to the services just described are summarized in Table 2.

Changes in Distribution System.

It is evident from this brief description of the distribution system that a large part of the Croton and all of the

Bronx and Byram supply, amounting to nearly half of the entire supply from municipal and private works, reaches the consumers from the sources in the upland watersheds without pumping; while the remainder of the city's supply, comprising that portion of the Croton that is raised to the High and Intermediate services in the boroughs of Manhattan and The Bronx, and all of the supplies of the boroughs of Brooklyn, Queens and Richmond from Long Island and Staten Island sources are pumped. Some of Brooklyn's supply from eastern Nassau County may even be pumped four times on its way to the high services of that borough. These facts should be kept in mind when the relative cost of operating the several portions of the present water works is considered. The economy of so far as possible substituting for these pumped supplies, the gravity supply from the new Catskill sources will then be evident.

The Catskill water will be delivered from Hill View reservoir at an elevation of 295 feet above sea level. This is high enough to serve, without pumping, all portions of the city now supplied, except a small portion of the Manhattan High Service on Washington Heights and the higher portions of Richmond borough. It is planned to supply with the first delivery of 250 million gallons per day from the Esopus watershed, all of the territory in the boroughs of Brooklyn, Queens and Richmond now served by the municipal works and to supply the High and Intermediate services in the borough of The Bronx, and in part the High and Intermediate services in Manhattan borough, the highest services being extended in all boroughs into such portions of the low service areas as are now inadequately served. All portions of Brooklyn and Queens can for the present be supplied by gravity, but later, when the highest ground in Queens is occupied, some water will have to be pumped. The lower portions of Richmond borough on which most of the population is located, will be served by gravity from the new Silver Lake reservoir at an elevation of 228 feet above sea level, but a small amount of Catskill water will have to be pumped to the highest service. The Bronx and Byram watersheds will be operated in connection with the Catskill works and the Croton system will continue to supply the Low services in The Bronx and Manhattan boroughs and in part the High and the Intermediate services of the latter borough. Except for the equipment necessary to pump a small amount of Catskill water to the higher portions of Staten Island, the operation of all the pumping stations now supplying The Bronx, Brooklyn, Queens and Richmond boroughs will be suspended.

TABLE 2. AVERAGE DAILY CONSUMPTION OF NEW YORK CITY IN 1915.

From Records of Department of Water Supply, Gas, and Electricity.

Borough	Service	Controlling Elevation of this Service Feet Above Sea Level	Source of Supply	Average Consumption in Million Gallons Daily
	MUNICIPAL WORKS			
Bronx	High	303	Croton	11
	Intermediate	193	Bronx and Byram	18
			Croton	16
	Low	134	Croton	23
				— 68

Manhattan	High	336	Croton	7	
	Intermediate	218	Croton	65	
	Low	219	Croton	201	273
Brooklyn	High	280	Ridgewood system	10	
	Intermediate	200	Ridgewood system	18	
	Low	172	Ridgewood system and Brooklyn wells	101	129
Queens	All services	148-221	Ridgewood system, local wells and Oakland Lake		13
Richmond	All services	143-254 and 453	Driven Wells		12
			Total Municipal Works		495
	PRIVATE COMPANIES				
Brooklyn	Flatbush Water Supply Co., Blythebourne Water Supply Co., German American Improvement Co.		Driven Wells		15
Queens	Citizens' Water Supply Co., Jamaica Water Supply Co., Queens County Water Co., Woodhaven Water Co., Urban Water Co.		Driven Wells		20
Richmond	South Shore Water Works		Driven Wells		0.1
			Total Private Companies		35
	Total Consumption from all Sources				530

It should also be noted that the Catskill aqueduct will be connected with the high pressure fire mains in Manhattan and Brooklyn, giving sufficient pressure for most fires without operating the High Pressure Fire stations.

Amount of Consumption.

Comparing the figures of average daily consumption in Table 2 with the estimates of dependable yield in Table 1, in the Bulletin of March, 1916, it is evident that the total supply of 341 million gallons per day which came from the Croton, Bronx and Byram systems, was within the estimated safe yield of these watersheds, as was the draft from the local driven-well stations in Queens borough; that the draft of 123 million gallons per day from the Ridgewood system somewhat exceeded the estimate of dependable yield of these sources of supply; and that the municipal works in the borough of Richmond were overdrawn.

That the consumption of New York City of 530 million gallons per day is now comparatively low may be seen in Table 3 which gives the total and the per capita consumption of the eight largest American cites, two of which have a higher proportion of metered services than New York.

Decrease in Per Capita Consumption.

The present water supply situation as regards the use of water in the city is best understood by comparing the present consumption with that of past years. In Table 4 are given the population of New York City and the average daily consumption in million gallons and per capita from 1885 to 1915 inclusive.

TABLE 3. CONSUMPTION IN LARGE AMERICAN CITIES IN 1915.

City	Estimated Population	Total Average Consumption Million Gallons per day	Average Daily Consumption Gallons per capita	Percentage of Services Metered
New York	5,585,800	530.	95	27.
Chicago	2,448,000	579.	237	6.6
Philadelphia	1,700,000	290.	170	7.7
Cleveland	765,000	80.	105	99.7
Boston	749,000	78.	104	53.
St. Louis (1914)	735,000	91.	124	7.
Baltimore	610,000	76.	123	3.3
Pittsburg	580,000	114.	197	22.

TABLE 4. POPULATION AND CONSUMPTION OF NEW YORK CITY

From 1885 to 1897 inclusive, estimates given for what is now the Borough of Manhattan and Borough of The Bronx west of the Bronx River, together with City of Brooklyn as constituted in given year.

From 1898 to date. Estimates given for the entire City of New York, all boroughs.

Year	Estimated Population Based on Federal and State Census	Average Daily Consumption in Million Gallons	Corresponding Average Daily per capita consumption in Gallons	Remarks
New York City (Manhattan and The Bronx) and Brooklyn before consolidation (Queens, Richmond, The Bronx east of Bronx River, and outlying wards of Brooklyn borough excluded).				
1885	2,034,000	138	68	
1886	2,121,000	144	68	Period of severe water shortage in New York and Brooklyn.
1887	2,164,000	145	67	
1888	2,210,000	153	69	
1889	2,307,000	155	67	
1890	2,339,000	174	74	New Croton Aqueduct opened July, 1890. New Ridgewood Conduit utilized December, 1891.
1891	2,412,000	211	87	
1892	2,536,000	231	91	
1893	2,629,000	251	95	
1894	2,716,000	247	91	
1895	2,784,000	256	92	New high service pumps in New York in operation in latter part of 1896.
1896	2,870,000	285	99	
1897	2,940,000	302	103	
City of New York (All boroughs as now constituted) Municipal and Private Supplies.				
1898	3,288,000	355	108	
1899	3,363,000	377	112	
1900	3,437,202	392	114	
1901	3,552,500	401	113	
1902	3,667,800	414	113	
1903	3,783,000	427	113	
1904	3,898,500	456	117	
1905	4,013,505	476	119	New Croton dam utilized.

1906	4,170,700	498	119	
1907	4,328,000	513	119	
1908	4,485,200	519	116	
1909	4,642,400	514	111	Vigorous water waste inspection begun, in Manhattan and Brooklyn, in 1910.
1910	4,799,639	529	110	
1911	4,956,900	494	100	
1912	5,114,100	505	99	
1913	5,271,300	499	95	Croton reservoirs low.
1914	5,428,500	544	100	
1915	5,585,800	530	95	

Note: Population 1885-1897 inclusive from estimates in J. R. Freeman's Report on New York's Water Supply 1900, and Report of Dept. City Works of Brooklyn, 1896. Figures 1898-1899 were extrapolated. Population 1900 and 1910, Federal Census; 1905 State census; 1905-1915 are in round numbers estimates made by Federal Census Bureau for June 1st of each year; 1901-1904 interpolated. Consumption 1885-1895 from J. R. Freeman's Report 1900 and Report Dept. City Works, Brooklyn, 1896, and estimates of Dept. Water Supply, Gas & Electricity; 1896 to date from Reports Dept. Water Supply, Gas & Electricity, and estimates of Board of Water Supply.

It may be seen that the consumption about reached the limit of our present water resources in 1910, and that the total consumption has remained practically stationary since that time, although the population has increased by nearly 800,000 in the same period. The per capita use of water has fallen off during this time over 20 gallons per day. This reduction in consumption, to which is due the present favorable relation of consumption to safe supply, was very largely the result of the efforts of the Department of Water Supply, Gas & Electricity to curtail the leakage in the street mains and to cut down fixture leakage by means of house-to-house inspections. This work was started vigorously in 1910. Among other causes which have contributed to keeping down the use and waste of water, perhaps the most important one is the generally low pressure that has been maintained in the distributing mains, a condition arising from the moderate elevation of the distributing reservoirs, the insufficient capacity of small or tuberculated street mains and the occasional throttling of the gates in the distributing system. The effect of such pressure conditions is familiar to all, a supply of water reaching perhaps only to the second or third floors of the houses, and a system of tanks and pumps to serve the upper floors. Special emphasis is laid on this point, because with the introduction of the first instalment of 250 million gallons of water from the Catskill system and with the generally higher pressures that will then be maintained, there will undoubtedly, be not only more leakage in the street mains and more unnecessary waste in house fixtures, but a greater legitimate use of water, resulting from better service and a belief that, with an abundance of water, strict economy in its use need no longer be exercised. In Table 4 the effect of a previous increase in the water supply in New York and Brooklyn is seen in the sharp rise in the amount of consumption upon the introduction of additional water through the New Croton aqueduct in 1890 and the New Ridgewood conduit in 1891. The change in New York in 1890 from a condition of acute water shortage to one of ample supply, raised the daily consumption of Croton water over 60 per cent. in six months, from 87 million gallons in June to 133 million gallons in December. If, through the introduction of the Catskill supply the per capita consumption should be only increased to that of ten years ago, say 120 gallons per day, which is not, under present conditions, an extravagant unit consumption for New York City, the present rate of growth in population would require in less than 20 years all of the present supply and the entire yield of the Catskill sources as well. In such event it would be necessary to anticipate the city's needs and within perhaps ten years seek new sources of water supply and incur still further financial burdens. Only effective measures looking to the curtailment of waste can keep down the consumption of water and defer indefinitely the building of new water works.

ARTICLE III. COST OF WATER, AMOUNT AND SOURCES OF WATER REVENUES AND AMOUNT OF WATER WASTED.

THE relative charges on the water from the several sources now supplying New York City shows the economy of temporarily abandoning the pumped supplies, when the Catskill water is introduced. A comparison of the total annual expenditures on the municipal water works with the amount of the annual revenues brings out the fact that, even with the great waste of water that now exists and the large volume of free water that is furnished for public uses, there is now an operating surplus which represents a good return on the present capitalization.

Cost of Present Water Supply.

Exclusive of the high pressure fire service, which is not properly a part of the water supply system, the city has spent, first and last, on the water works now supplying the city $190,516,000
of which there remains a bonded indebtedness of.... 84,565,000

In 1915 the annual fixed charges on these outstanding bonds and the total expenses of operating the present works were estimated at $8,415,000
which represents an average charge on the daily supply of 495 million gallons furnished in 1915 by the municipal works of 46.58
per million gallons.

This cannot be considered the cost of the present supply, since the true cost must also take into account that portion of the expenditure on the works which has been amortized. On the basis of the original cost of the works and the present operating charges, there would be an average charge on the present supply of $78. per million gallons.

The relative charges on the present water supplies of the several boroughs of the city in 1915 and the proportion of these charges, belonging to fixed charges and to operating expenses, are shown in Table 5.

TABLE 5. CHARGES ON THE MUNICIPAL WATER SUPPLY OF NEW YORK CITY IN 1915.*

From Estimates Made by the Department of Water Supply, Gas & Electricity

Boroughs	Estimated Original Total Cost of Works Dec. 31, 1915	Estimated Present Bonded Indebtedness on Existing Systems—Dec. 31, 1915	Present Annual Interest and Sinking Fund Charges, Based on Interest 4.5% Sinking Fund 0.888%	Average Daily Supply in 1915 Million Gallons per Day	Average Charges on One Million Gals. on Basis of Interest and Sinking Fund Charges	Annual Cost of Operation 1915	Average Charges on One Million Gals. on Basis of Total Operating Cost	Total Charges on One Million Gals. Based on Fixed Charges and Operation
Manhattan & Bronx	$138,424,000†	$55,950,000†	$3,014,000	341	$24.22	$1,655,000	$13.29	$37.51
Brooklyn	43,856,000†	21,358,000†	1,151,000	129	24.44	1,708,000	36.27	60.71
Queens	4,022,000	3,073,000	166,000	13	34.98	259,000	54.58	89.56
Richmond	4,214,000	4,184,000	225,000	12	51.37	237,000	54.11	105.48
Totals & Averages	$190,516,000	$84,565,000	$4,556,000	495	$25.22	$3,859,000	$21.36	$46.58

*These estimates do not include the cost of the water works owned by private water companies or the charges on these works which are borne by the consumers served by them.

†Exclusive of High Pressure Fire Service.

It is evident that the largest and likewise the cheapest of the pumped supplies, that of Brooklyn, was over 50 per cent. more expensive than the gravity supplies of the boroughs of Manhattan and the Bronx. This difference is, of course, to be found in the expenses of operation which are but little over $13 per million gallons for the Croton, Bronx and Byram supplies of the boroughs of Manhattan and The Bronx, against a sum of over $36 for the Ridgewood and local driven-well supplies of the borough of Brooklyn. It should be noted that the cost of operating the works supplying the boroughs of Manhattan and The Bronx includes the charges on the pumping stations in those boroughs which will be partly shut down when the Catskill supply is delivered.

Cost of Catskill Supply.

According to estimates in City Record of Dec. 31, 1915, there will have been expended on the Catskill works, upon the completion of that portion now under construction to bring in 250 million gallons per day from the Esopus watershed,...$140,000,000

The proposed Schoharie works are estimated to cost when finished	22,250,000
Additional construction on Catskill Aqueduct required for full capacity	$4,000,000
Total cost of Catskill system when completed to full capacity of 500 million gallons per day	$166,250,000
The total annual interest and amortization charges on the completed Catskill works will then be about	8,675,000
The estimated annual operating and maintenance charges	3,000,000
The total annual fixed charges and operating expenditures on reservoirs and transportation works	$ 11,675,000
Of which the new construction on the Schoharie watershed and the main aqueduct may properly be charged with	$ 1,400,000
Including the charges on additional construction in the distribution system chargeable to the new works, the total annual expenditures for the Catskill supply are estimated as	$ 12,100,000
From which the final cost of the 500 million gallons per day of the Catskill supply will be	$66

per million gallons.

Until the Catskill works are completed and the system is operated at full capacity, the unit cost per million gallons of water supplied will, of course, be considerably larger than the above figure.

Economies of the New System.

The temporary abandonment of the present sources of supply on Long Island and Staten Island and the suspension of most of the present pumping in the city, which will occur upon the introduction of the Catskill supply, will effect the following operating economies on the works now supplying the City:

Boroughs of	Estimated Saving
Manhattan and The Bronx	$ 41,500*
Brooklyn and Queens	1,186,800*
Richmond	150,700
Total saving in operation	$1,379,000

*With the high pressure fire mains connected to the City tunnel of the Catskill Aqueduct, it will not be necessary to operate the high pressure fire service stations for many first alarm fires, and a still further saving not here estimated may be effected. This will be offset, however, by expenditures for the care of the works that are to be shut down but held in reserve.

The saving in operation that will be effected by placing in reserve the present supplies of the Boroughs of Brooklyn, Queens and Richmond will evidently just about pay the total charges on the new construction required to complete the Catskill works. At practically no greater cost, the City will have secured from the Schoharie watershed a supply nearly twice as great as the dependable yield of the works temporarily abandoned on Long Island and Staten Island, and will have added to its permanent possession a better and more reliable supply.

In addition to the economies effected by the suspension of the operation of the municipal works, the proposed increase

in pressure throughout many districts of the City will permit of a large saving in private pumping, which has been estimated as high as $1,000,000 per year.

Necessity of Completing Catskill Works.

Neglecting the amount of water which may be diverted from the Catskill works for other municipalities, it is estimated that under present conditions, the normal rate of growth of New York City and the probable rise in per capita consumption, incident to the delivery of the new supply, will so increase the draft upon the gravity supplies from the Esopus, Croton and the Bronx and Byram watersheds that the consumption of the City will begin to approach the dependable yield of these sources by the time the supply from the Schoharie watershed is ready. No practicable measures of water waste prevention can reduce the amount of consumption rapidly enough to safely permit the Schoharie project to be deferred. If the Schoharie supply were not available when the other gravity supplies are exhausted, it would be necessary to resume the operation of the Long Island or Staten Island works. That some of the ground water supplies from these works have become objectionable for both domestic and industrial uses, because of the infiltration of sea water and the encroachment of the population on the watersheds, makes it highly probable that, except as no other supply is available, a portion of the present works on Long Island and Staten Island, when once abandoned, will never again be operated. Remembering that it required repeated shortages of water and something like ten years of agitation to secure authorization for the construction of the Catskill works, it must be obvious that a like inertia would doubtless have to be overcome in the future when the needs of the City require an additional supply of water. The building of a large water supply project takes many years, and ordinary prudence demands that construction work anticipate the actual needs of a great city. With all these considerations in mind, and realizing that until the Schoharie works are finished, a portion of the cost of the Catskill aqueduct, operating at but half of its capacity, will represent an idle investment, the wisdom of acquiring the Schoharie sources and completing the Catskill works is beyond question.

Present Water Rates.

Under the provisions ofthe Charter of Greater New York and the ordinances of the Board of Aldermen, the Commissioner of Water Supply, Gas and Electricity has required all water used for business purposes to be measured by meters, except that sold to shipping on the water front and that used for building construction, street sprinkling and some other minor uses. This metered consumption bears the uniform rate, fixed by the Code of Ordinances of the city of New York, of 10 cents per 100 cubic feet, which is equivalent to $133.68 per million gallons or 13.4 cents per 1000. gallons. The remainder and by far the larger portion of the supply, which aside from the water front use, building construction, etc., is furnished for domestic consumption to apartment houses, tenements, flat houses and private dwellings is not metered, except at the option of the owner. Without further action by the Board of Aldermen, it is considered doubtful if it is even legal to permit any metering whatever of domestic consumption.

Water for domestic use is paid for on the basis of frontage rates and special charges, fixed by ordinance of the Board of Aldermen as follows:

Front Width of Premises in feet	Annual Rent*				
	1 story	2 stories	3 stories	4 stories	5 stories
16 and under	$4.00	$5.00	$6.00	$7.00	$8.00
16 to 18	5.00	6.00	7.00	8.00	9.00
18 to 20	6.00	7.00	8.00	9.00	10.00
20 to 22½	7.00	8.00	9.00	10.00	11.00
22½ to 25	8.00	9.00	10.00	11.00	12.00
25 to 30	10.00	11.00	12.00	13.00	14.00
[illegible] 37½	12.00	13.00	14.00	15.00	16.00
[illegible] 50	14.00	15.00	16.00	17.00	18.00

The apportionment of the regular frontage rates upon the dwelling houses is on the basis that but one family is to occupy the same, for each additional family one dollar per year shall be charged.

Building Purposes: Ten cents per 1,000 brick. All masonry at the same rate, 500 brick being equal to one cubic yard.

Plastering—Forty cents per 100 square yards, openings not included.

Baths—Three dollars per annum.

Water closets and Urinals of every description—Two dollars per annum. One Water Closet and one Bath in each house supplied free of charge.

Steam lighters and tug boats, H.P.	per year	$90.00
Steam lighters and tug boats, L.P.	per year	45.00
Pile drivers and hoisting engines	per month	5.00
Steam yachts	per month	5.00
All others	per month	5.00
Water boats supplying shipping	per month	25.00

In addition there are a number of rates for services properly metered that may be charged while meter is being installed.

*It is of interest to note that in general these frontage rates are lower than those first established by the Common Council of the city in 1850.

Amount of Revenue in 1915

The above rates yielded a total revenue in 1915 of $13,181,015, which was derived from the following sources:

Meter rates, mostly business and industrial consumption, including penalties		$6,401,324
Frontage rates and special charges for domestic use, including penalties		6,517,402
Special charges, building construction	$167,839	
Water front, shipping use	46,087	
Street sprinkling	4,795	
Hose permits	20,335	
		239,056
Sale of ashes and other materials		23,233
Total revenue, 1915		$13,181,015
Deducting from this sum the total operating expenses and fixed charges, last year, exclusive of the High Pressure Fire Service, of		8,415,000
Leaves an annual operating surplus for 1915 of		$4,766,015

When the Catskill works, now approaching completion, are turned over to maintenance, an annual operating deficit of about $1,000,000 is estimated, which will have to be made up from general taxation. If, however, the municipal water works were given credit for water used for various public purposes, for which no record is even kept, there would still be a large surplus of income over expenditures. The public use and waste of water for street cleaning, sewer flushing, and for the supply of public buildings, is probably, at a moderate estimate, as much as 30 million gallons per day, which at meter rates is worth nearly $1,500,000 per year. In addition to the above amount, the water works of the city might also be credited with a payment of say $40. for each hydrant that is installed and maintained for fire protection, just as the private water companies are now paid for this service out of the tax levy. The additional income from this source on the 44,000 hydrants in the city would amount to $1,760,000 per year. It is certainly not businesslike to furnish water without compensation for all public purposes and thereby support indirectly out of water revenues many activities which are more properly a charge on general taxation. Some day, when better municipal book-keeping

methods prevail, all uses of water will be accounted for and credits to water revenues will be made for all services rendered by the municipal water works, just as in some of the well administered cities of Europe, where even the water used from the hydrants for flushing the streets is measured and accounted for.

Amount of Water Wasted.

In their use of water as in the employment of their other natural resources, the American people have often exhibited a prodigality which is a constant source of wonder to the water supply engineers of Europe, where the per capita consumption of water is seldom a third of the quantities used in the larger cities of this country. A part of this difference is due to the higher standards of living in this country, as evidenced by the larger number of water closets, bath tubs and other fixtures in American cities and to the greater use of public supplies for manufacturing purposes here, but a large portion of the excess in the use of water in this country represents actual waste in the street mains and in the house fixtures and connections. As previously pointed out, New York City has the lowest consumption of any of the large American cities, yet the waste here is great and is likely to be still greater when better service is provided.

The average daily consumption in 1915 of 95 gallons per capita may be approximately subdivided as shown in Table 6. It should be understood that many of the figures in this table are but rough approximations, based upon observations in a few districts in New York City and upon records from other municipalities; they give, however, some idea of the actual waste of water and indicate where the greatest efforts in waste prevention should be made. It appears that the actual use and unavoidable waste is about 75 gallons per day per capita and the preventable waste about 20 gallons. Under ideal conditions of operation, an average per capita consumption of less than 75 gallons a day might be possible in the course of time, but for the present this is about all that may be reasonably anticipated after a number of years of persistent, intelligent effort directed towards the reduction of waste. As manufacturing increases in the city and the non-resident population of something like 500,000 grows with the development of suburban life, it is quite possible that even this figure may never be realized. Compared with other large American cities, in which a high percentage of the services are already metered, a consumption of 75 gallons per capita seems low, but comparisons with other cities are misleading without some knowledge of the relative amounts of water that are supplied for industrial uses and domestic consumption and without some information regarding the class of consumers supplied. If, for example, the daily industrial use of water in Cleveland, the largest of our most completely metered cities, were the same as that of New York City, namely, 25 gallons per capita, instead of 60 gallons as it is, the total average daily consumption in Cleveland would be about 70 gallons per capita, instead of 105 gallons. On the other hand, many of our smaller manufacturing cities which are completely metered and use only 40 to 60 gallons per capita daily, are located on fresh water streams and draw little water from the public mains for industrial purposes.

Large as the unnecessary waste of water in New York City is believed to be, attention should be called to the fact that this waste cannot be eliminated at once, but must be slowly curtailed by the steady patient efforts of many years. The best result which can be anticipated from any system of water waste prevention, during the first few years of improved service following the introduction of the Catskill supply, is that the per capita use of water will be kept within the moderate limits at which it has recently been held.

TABLE VI.

PROBABLE SUB-DIVISION OF PER CAPITA CONSUMPTION OF WATER INTO USE AND WASTE IN 1915.

	Gallons per capita per day
Actual Use	
Domestic consumption:—average of all classes of consumers, 10-15 gallons in tenement districts, to 50-75 gallons in high-class apartments, estimated	30
Business use:—Manufacturing and commercial all now metered except waterfront consumption, computed from revenues from metered consumption	25
Public use, parks, street sprinkling and cleaning, sewer flushing, fountains, fire service, and public buildings and hospitals, estimated	5
Total real use	60
Unavoidable Loss and Waste.	
Incurable leakage in 2,900 miles of street mains and in house connections, made up of innumerable small leaks, each too small to be readily discovered or to be worth the cost of digging up the pavement to stop, estimated	5
Fixture leakage, under registry of meters, and unnecessary or extravagant use of water in careless or improvident households, which cannot altogether be checked by the most complete system of meters or the most efficient inspection, estimated at	10
Total unavoidable waste	15
Total use and unavoidable waste	75
Needless and Curable Waste.	
Obscure leakage of some magnitude in street mains, from broken pipes, faulty joints and abandoned services which occasionally give evidence in basements and sewers, otherwise only discoverable by careful gauging and full accounting of all consumption, approximately estimated at	3
Waste in unmetered public buildings, in street and sewer flushing and other public uses, including unnecessary free water, estimated roughly	2
Waste from defective fixtures and from careless or willful use of water, now believed to be large, with practically all domestic consumption on flat rates, estimated	15
Total unnecessary waste	20
Total average daily consumption in 1915	95

ARTICLE IV. PREVENTION OF WATER WASTE AND EQUALIZATION OF WATER RATES

NO valid objection can be offered to the extension of the meter system to such business uses as shipping and building construction, which are still supplied with water at special rates; nor can there be any effective argument made against properly measuring and accounting for the large amount of water now furnished free for all public and charitable purposes. The great problem in water waste prevention in New York City is that of doing away with unnececssary domestic waste, which represents perhaps three-fourths of the entire preventable loss. The elimination of this waste requires the

adoption of such measures that, while surely cutting off the unnecessary waste, will assure to all consumers at a reasonable price, a sufficient supply of water for all legitimate needs, and at the same time, give the city a revenue that will more than cover all expenses and provide a sufficient balance to meet all water supply obligations.

General Metering.

The most effectual and economical means of eliminating the present waste of water in New York City, that occurs inside the building lines, is to place a meter on every service connection, either for private or public use, and follow it up by faithful inspection, frequent testing and repair of meters, and frequent presentation of water bills. The present method of house-to-house inspection has been efficient, at times of imminent water shortage, in materially reducing the loss of water through leaky fixtures, but, for the best results, the consumers must realize the necessity of such inspections and co-operate. At best, this method of reducing waste must be considered an emergency measure to be adopted only during periods of deficient supply. Occasional inspections cannot permanently prevent the losses through leaky fixtures, particularly through those of the cheap and inferior grades of plumbing, which require constant attention; nor can such inspections curtail the careless or wilfully extravagant use of water, because, unlike the meter on the service pipe, the waste inspector cannot always be "on the job." General metering offers a sure means of preventing waste, whether there be an abundant supply of water or not, because, with a meter on every service, each careful citizen who has to pay for the water becomes an efficient water-waste inspector. He is at once financially interested in installing good plumbing and keeping it tight, and may be depended upon, without municipal inspection, to keep the use of water within reasonable bounds.

A well-administered system of metering offers little opportunity for friction between the water department and the consumer. The regular quarterly visits of a meter inspector to read the meter must certainly be less annoying to the householder than the occasional calls of a water-waste inspector who must see every fixture in the house.

District meters, pitometer measurements and other means familiar to the engineer make possible the discovery of leaks in the street mains. When all water delivered to the consumers is metered on the premises, the search for large losses in the street mains will be much simplified.

Experience in Other Large American Cities.

Some years ago, the system of house-to-house inspection was tried out in Boston, Mass., in connection with the use of the Deacon waste-water meters which had given satisfaction in many English cities. Good results were obtained in Boston as long as the system was efficiently maintained, but the cost was considered out of proportion to the amount of water saved and was finally abandoned. Large district meters of the Venturi type have since been installed in the distribution system and the house services have been progressively supplied with meters until now 53 per cent. of all connections are metered. The amount of consumption and the proportion of services metered in Boston during the last ten years are shown in Table 7, which shows the steady decrease in the per capita use of water that has been effected by the meters. Equally striking are the results that have been obtained in Cleveland, Ohio, which is now the most completely metered of our large American cities. In Table 8 it is seen that, in 1901, the total average daily consumption in Cleveland had increased to 70 million gallons per day and the daily per capita consumption to 169 gallons. As meters were installed, during the next seven years, the consumption fell off rapidly until about 94 per cent. of the services were metered, when the average daily use of water was but 52 million gallons and the daily per capita consumption only 100 gallons. Since 1909, the consumption has slowly increased with the growing population and the average daily per capita consumption has fluctuated from 94 to 110 gallons. In 1915 with practically all services metered, the daily consumption was about 80

million gallons or 105 gallons per capita. The effect of metering on the consumption of Boston and Cleveland is brought out clearly in the diagram on page 19.

Table 7.

RESULT OF METERING IN BOSTON, MASS.

From Annual Reports of Metropolitan Water and Sewerage Board.

Year	Estimated Population Supplied	Total Consumption in Million Gallons per Day	Corresponding per Capita Consumption	Per Cent. of Services Metered
1906	601,430	91	151	5.5
1907	612,580	96	157	5.5
1908	622,760	98	158	5.7
1909	632,960	94	149	12.2
1910	674,400	87	130	20.0
1911	688,520	86	124	27.3
1912	718,900	90	125	34.8
1913	733,360	79	108	41.4
1914	747,830	81	109	47.4
1915	749,000	78	104	53.2

Table 8.

EFFECT OF GENERAL METERING ON CONSUMPTION OF THE CITY OF CLEVELAND, OHIO.

From Annual Reports of the Water Department of Cleveland.

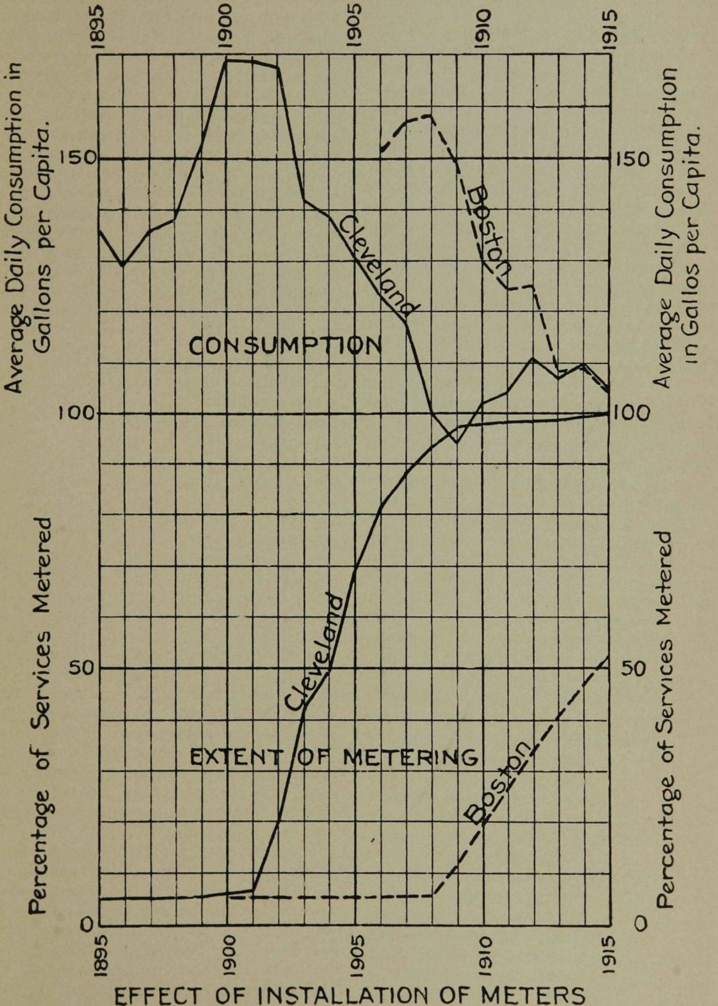
Year	Population	Average Daily Consumption in Million Gallons	Corresponding Average Daily Consumption in Gallons per Capita	Per Cent. of Services Metered
1895	345,000	47	137	5.0
1896	354,000	46	129	5.1
1897	356,000	48	136	5.1
1898	375,000	52	138	5.2
1899	403,000	62	153	5.4
1900	398,000	67	169	5.9
1901	412,000	70	169	6.4
1902	416,000	70	168	19.9
1903	437,000	62	142	42.8
1904	444,000	61	139	50.1
1905	461,000	60	131	69.7
1906	480,000	59	123	82.2
1907	500,000	59	118	88.6
1908	520,000	52	100	93.6
1909	564,000	53	94	97.5
1910	603,000	61	102	97.7
1911	630,000	66	104	98.3
1912	660,000	73	111	98.4
1913	715,000	77	107	98.5
1914	745,000	82	110	99.5
1915	765,000	80	105	99.7

Effect of Installation of Meters

The increase in per capita consumption in Cleveland after most of the meters were installed, an occurrence which has been frequently noted elsewhere, should not be interpreted as an indication of the failure of this method of water waste prevention. The increase in Cleveland in 1910 has been attributed to the policy adopted, that year, of making fewer meter readings and inspections. Every householder cannot be depended upon to watch his meter and stop his leaks, if his attention is not frequently called to them. Such increases in consumption, as noted in Table 8, often occur, however, because of an increase in the legitimate use of water, due to better houses and more fixtures or to fluctuations in the volume of business done. Even with meters, severe winter temperatures may cause a larger domestic use or waste of water to keep the pipes from freezing, or hot summer weather may lead to increased consumption in order to get cooler water from the fixtures and to irrigate lawns and gardens. But for the meters, such temperature changes would undoubtedly cause a much greater use of water. Whatever the cause of such increases in consumption, with a meter system the city secures additional revenue from the greater amount of water supplied.

Experience has shown everywhere, however, both in this country and abroad, that the general installation of meters will reduce the consumption. The success of general metering in cutting down the consumption of water in Lowell, Mass.; Hartford, Conn.; Richmond, Va., and Houston, Tex., and in keeping down the consumption in Providence, R. I.; Worcester, Mass., and many other cities, large and small, throughout this country, is sufficient proof of the wisdom of those who have adopted this method of conserving the most important of our natural resources. An interesting case in point is that of Hamburg, Germany, which used, 20 years ago, 50 gallons of water per capita daily. By gradually placing a meter on every consumer, this comparatively low consumption was reduced by 1909 to a daily use of only 37 gallons per capita and a sufficient time

was obtained, by thus reducing the amount of water required, to thoroughly investigate additional sources of supply and construct new works before the real need for additional water occurred. Attention has already been



EFFECT OF INSTALLATION OF METERS ON CONSUMPTION OF WATER IN THE CITIES OF BOSTON, MASS. AND CLEVELAND, OHIO.

called to the low standards of comfort as measured by the meager plumbing in European cities, which largely account for such low unit consumptions.

City Ownership of Meters

Among the many changes necessary to a proper administration of a meter system in New York City, perhaps the most important to be effected is that of the ownership of the meters. The city, instead of the property owner or tenant, should own, install and maintain the meter as well as the house connection from the street main to the building line. The consumer would not then be exposed to the extortions of the plumber, and the Water Department would be in a position to take out and replace the water meter for test or repairs at any time without friction with the owner or tenant and without losing any part of the meter record. A good type of meter should be adopted by the city, one that will register small flows and require a minimum of attention for testing and repairs. Existing meters, if in good condition and of a satisfactory type, would be maintained along with those installed by the city. To avoid injustice to property owners who have purchased meters under the present regulations, it might be reasonable to pay the owner on some equitable basis for such meters, whenever it becomes necessary to replace them. Under a system of complete municipal ownership and inspection, the defective or fraudulent meter, which is occasionally found, could soon be eliminated.

Liability for Payment of Water Rates.

The practice in regard to fixing the liability for the payment of the water rent differs widely in different communities. In the administration of municipal water works, it is generally customary to look to the property owner for the water rent and even some private water companies insist upon dealing entirely with the property owner. Among private water companies, the practice of billing the tenant for the water appears, however, to be more general, and some municipalities do business this way. Under the somewhat unusual provisions of the present New York City charter, which insures the payment of water rent by making it a lien on the premises supplied, the property owner here must pay the water rent and provide for the distribution of the water to his tenants. Universal metering of the domestic consumption would no doubt lead, in time, to the adoption of the practice now quite general on metered premises of providing in the lease that the tenant would pay the water rent. In other metered cities no serious difficulties, so far as known, have arisen through the tenants wasting the water or refusing to pay for it, but, on a service supplying more than one tenant, it is no doubt difficult, without submetering, that is, without an independent meter for each tenant, to properly apportion the charges and equally difficult to discover among several consumers, any wilful or careless waste of water.

A Meter for Each Householder.

Perhaps a better solution of the meter problem than that which has been adopted elsewhere would be for the city to place a meter on the pipe supplying each householder or tenant and transfer from the property owner to the tenant the obligation to pay for the water. This plan would require an advance payment or deposit by the tenant in accordance with the practice of the gas and electric light companies in order to cover the cost of the meter and insure payment for the water. The metering of every dwelling, apartment and flat would, of course, relieve the property owner of any financial loss or any friction with his tenants and would make each tenant an inspector of his own plumbing and his consumption of water. Such a system, if properly maintained, would necessarily be more effective in cutting off the waste in a tenement or apartment house than one in which a meter is placed only on the service pipe leading to the building. In many respects, the individual family meter is ideal, but it would be expensive and would mean in most families an additional expenditure for a service which, in case of the tenant, has hitherto been inadequately paid for by the landlord under the present flat rates and included in the amount of the rent.

Service and Minimum Charges.

In order to insure the financial suc-

cess of any system of general metering, a service charge must be levied on each consumer to provide for the cost of installation, operation and maintenance of the meter, and to cover the value of the small amount of leakage that may pass the meter without registering, and a minimum meter charge must be fixed, which shall correspond to a reasonable minimum use of water at meter rates. The service charge should be payable in advance upon the installation of the meter and at the beginning of each water year thereafter, under the penalty of removing the meter and discontinuing the service. Without any allowance for the house connections, this charge would be about $3 per year for the smallest meters and correspondingly more for the larger sizes. If meter readings were made quarterly as they should be for the most effective operation of a meter system, the minimum charge may be rendered on the quarterly bills when the amount of water registered for the preceding quarter is less than the allowance corresponding to the minimum charge. This minimum charge, ordinarily based upon the size of the tap or connection or better still, on the number of persons or families supplied, would be in the neighborhood of $3 to $4 per year or $0.75 or $1.00 per quarter for the smaller services. If payment of water bills be required less frequently than once every three months and the water rent is not secured as now as a lien on the real estate, the minimum charge might have to be exacted in advance when the service charge is paid for, and credit given later on the meter bills.

Program for Installation of Meters.

The first step in the extension of the meter system in New York should be that of at once completing the metering of the water supplied for business uses, by placing meters on the connections along the water front where water is now furnished at flat rates, and requiring that all water for building construction and other such purposes be measured. After this is accomplished, all domestic consumption should be metered. At least ten years would be required to place meters on all domestic services, if the most energetic measures be adopted and the usual plan of placing a meter on every house connection is followed. From a financial standpoint, it would be to the City's advantage to first install meters on the larger apartment houses, and finally place them on the less profitable services in the one- and two-family houses. It would be good policy, however, to first entirely meter the highest services of the city, to which water must still be pumped after the introduction of the Catskill supply, since every gallon delivered to such districts represents a real additional expense to the city. Before insisting on the complete metering of domestic consumption, the city would perhaps do well to set the public a good example and eliminate the municipal waste of water, by installing meters on all public buildings and providing for the measuring, so far as possible, of all water used for public and charitable purposes.

Objections to Universal Metering.

Aside from the difficulties of control by the property owner of the consumption of water in his building and the annoyances of adjusting the payment of water rates between the owner and tenant, already discussed, and the question of the financial advantage to the city of general metering which will be considered later, the objection which has been most often raised in New York to domestic metering, is that such a system would operate to deprive the consumers of the amount of water necessary for their health and comfort. This objection is without foundation. Certainly no sign of any decrease in the healthfulness of New York City has appeared as a result of cutting down the per capita use of water by 20 per cent. in the last ten years. The metering of Cleveland in the years following 1900, which resulted in the cutting off of so much waste, was done without adversely affecting the health of the city. In fact, with practically every consumer metered, the death rate is now lower than when the metering began, and Cleveland is one of the healthiest cities in the country. The health of Boston has also steadily improved although the number of meters has been greatly increased.

By fixing a minimum charge to each

domestic consumer that will correspond at meter rates to a liberal supply of water for all domestic purposes, the use of sufficient water can be assured. Every consumer is entitled to enough water for all legitimate uses at as low a price as the city can afford to give it to him, but no consumer can possibly receive any benefit in health or in pocket from the water that escapes from leaky plumbing or that is allowed to carelessly run from his fixtures into the sewer. The popular notion, so often heard, that water should be as "free as air" can hardly be held in a modern urban community when it costs from $50 to $70 per million gallons to collect, transport, purify and distribute a supply from distant sources.

Financial Advantage of General Metering.

It has already been pointed out that a cutting down of the amount of the consumption by the general use of meters would defer the acquisition of further new sources of supply, always more distant and more expensive, and thus avoid for many years any new financial burdens. Within the city the adoption of a policy of general metering would not only eliminate the present needless domestic waste and, by reducing the draft in the smaller distribution mains, increase the pressure and defer the replacement of many of the old mains; but such a plan, by equalizing the present water rates and providing proper charges for the service rendered, would also insure additional water revenues to the city and avoid any charge on the tax levy for the operation and maintenance of the water works. It will be shown that the frontage charges and special rates by which practically all water for domestic consumption is sold are lower than the meter rates even on the basis of a minimum use of water for actual needs. Considering the amount of water that in the aggregate is wasted by the unmetered domestic consumer, it will be demonstrated that the price paid by him for the water that actually goes through his fixtures is ridiculously low. When the expense of municipal government lays a heavy burden of taxation upon the real property in the city, the opportunity of securing legitimate additional revenue from the water supply by charging an adequate price for the water delivered should not be overlooked.

Comparison of Meter and Flat Rates.

The unit price received for the water furnished on flat rates may be approximated from an estimate of the total supply provided for unmetered domestic consumption, and the actual revenues received in 1915 as follows:

		Million Gallons
From the total average daily municipal supply in 1915		495
Deduct the following:		
The average daily amount of water used for business and industrial purposes, including small amount for domestic consumption which was sold by meter, as estimated from the revenues of $6,401,324 received on metered accounts at 10 cents per 100 cu. ft.	131	
The amount sold on flat rates for building construction, shipping and other business purposes, estimated roughly from revenue of $239,000	7	
Amount of free water now used on the average for all public and charitable purposes, estimated roughly in Table 6 for entire city at 7 gallons per capita on estimated population supplied by municipal works of 5,000,000	35	
Average amount of water estimated to be lost daily in street mains and house connections outside of building lines, say 8 gallons per capita on estimated population supplied of 5,000,000 (See Table 6)	40	
Total deduction		213
Remainder of supply in 1915 representing probable average amount of water delivered for domestic consumption, includ-		

ing that actually used and that wasted by leaky fixtures and careless or wilful use	282
Corresponding amount in million gallons for the entire year	102,930
Total revenues received from frontage accounts excluding water for business purposes on water front	$6,517,402
Unit price received per million gallons for the water furnished for domestic purposes on frontage rates, including that wasted in unmetered dwellings	$63
Equivalent price of this water used and wasted, per 100 cu. ft.	4.7 cents

The foregoing tabulation shows first, that the quantity of water used and wasted on premises, which are taxed on the basis of frontage rates and special charges, is somewhat more than twice the amount of water sold at meter rates, and second, that unit price received by the city for the water that is supplied to unmetered premises is less than one-half the rate of 10 cents per 100 cubic feet borne by the metered supply.

Additional Revenues from General Metering.

If the entire amount of water which is estimated as going to the unmetered consumers were actually paid for at the meter rate of 10 cents per 100 cu. ft. instead of about 4.7 cents, the city would receive about $7,300,000 more each year in increased revenues. The result of installing meters on domestic consumption would, however, be a gradual reduction in the present waste, which, with the increased cost of administration, would, to some extent, offset the increase in revenues due to the larger unit charge. Suppose, by way of illustration, that by universal metering the total daily consumption of water in 1915 had been only 75 gallons per capita, reducing the actual domestic use to only 30 gallons per capita, as estimated in Table 6. Then the average daily domestic supply delivered to unmetered premises, including the estimated unavoidable leakage and waste in house fixtures of 10 gallons per capita, would have been about 200 million gallons per day instead of 282 million gallons, as above estimated, and the revenue of $6,517,402 received from unmetered consumers in 1915, would represent a rate of 8.9 cents per 100 cu. ft., which is only 1.1 cents less than the meter rate. Complete metering of domestic consumption would, therefore, have yielded in 1915, if all needless domestic waste had been cut off, an additional gross revenue of about $1,070,000. Such a sum would not represent, however, a clear gain, because the operating charges would increase with the number of meters installed.

Cost of Meter System.

The average cost of installing and operating meters, small and large, of the better, though of the more expensive type, such as would be placed on domestic services, is estimated liberally at $3.00 per year for each meter, as follows:

Interest on average cost of furnishing and installing meter, all sizes, $15 at 4½%	$0.68
Replacement in 20 years	0.70
Maintenance, testing and repairs, estimated	0.60
Reading meter and computing records	1.00
Total	$2.98

This sum does not cover the installation of the house connection by the city.

Net Gain from General Metering.

Deducting from the estimated gross increase in revenue resulting from complete metering, namely, $1,070,000, the total cost of operating the meters, that would be required on the 276,281 services that were unmetered in 1915, at $3 per meter = $828,843, or say $850,000, to cover increased office expenses, supervision and new equipment, there would have been a net financial gain from universal metering of only $220,000 per year. If we assume that the daily domestic consumption and unavoidable waste passing the meters had not been as low, in 1915, as 40 gallons per capita, the increase in revenue to the city from this source would be correspondingly greater than that estimated. By levying a moderate service charge on each consumer, such as customarily applied,

ample revenues would have been obtained under the conditions assumed to meet all water supply expenses.

If a meter should be placed on every private dwelling, apartment and flat, as suggested in this article, there would possibly be 1,000,000 or more meters in use on the domestic consumption, and since we may assume the cost of operating all these small meters, many grouped together in one building, at a somewhat lower price than above, say at $2.75 per meter, the increased cost of operation would be $2,750,000 a year plus some additional administration charges. A service charge of at least $3 per year, over and above the charges for water consumed would, therefore, be necessary under this plan of metering, to cover the expenses of operation, providing as low a per capita consumption as that estimated should be realized. Even with this extra charge, the entire cost of the water that would be delivered under well-considered minimum rates would be very reasonable and the burden of expense would be assessed where benefits were received.

Recent Legislation.

Since these articles were prepared the Water Meter Bill, Senate Int. 1125, Assembly Int. 1393, has passed the Legislature and received the approval of the Mayor and the Governor. This bill permits the domestic consumer to apply for a meter if he chooses to have one and legalizes the present metering of a portion of the domestic supply. It still leaves the power to fix the amount of the water rates and to decide the classes of buildings to be metered in the hands of the Board of Aldermen which has been in a position to authorize general metering for many years. The new law does, however, permit the Board of Aldermen to meter one class of consumers without metering all, which is a decided advantage in carrying out a well-considered program of progressive metering. The new legislation furthermore permits the Department of Water Supply to install meters. Altogether the new legislation represents a decided step in advance and should pave the way for further necessary changes in the present water laws.

Well Worth Doing

The objects of the Corporation are:

1st. The formation of an Association of those professionally engaged in the Real Estate Business, Land Owners and persons interested in Real Estate and the welfare of our STATE and CITY and to make the Board the centre of Real Estate Interests in New York.

2d. To protect and promote the mutual interests of its members, and to facilitate negotiations in Real Estate.

3d. To promote and encourage the enactment of laws beneficial to and take united action upon legislative and municipal matters affecting Real Estate.

4th. To oppose and take necessary measures to prevent the enactment or enforcement of unjust or obnoxious legislation, and secure an efficient and economical administration of the affairs of the STATE and CITY.

5th. To secure an equitable and uniform system of taxation.

6th. To advocate necessary public improvements and oppose unnecessary, extravagant and wasteful expenditure of public funds.

[*Preamble to Constitution, Real Estate Board of New York.*]